Eucalyptus wood phenotyping by Near Infrared Spectroscopy for chemical compounds, basic density and moisture content

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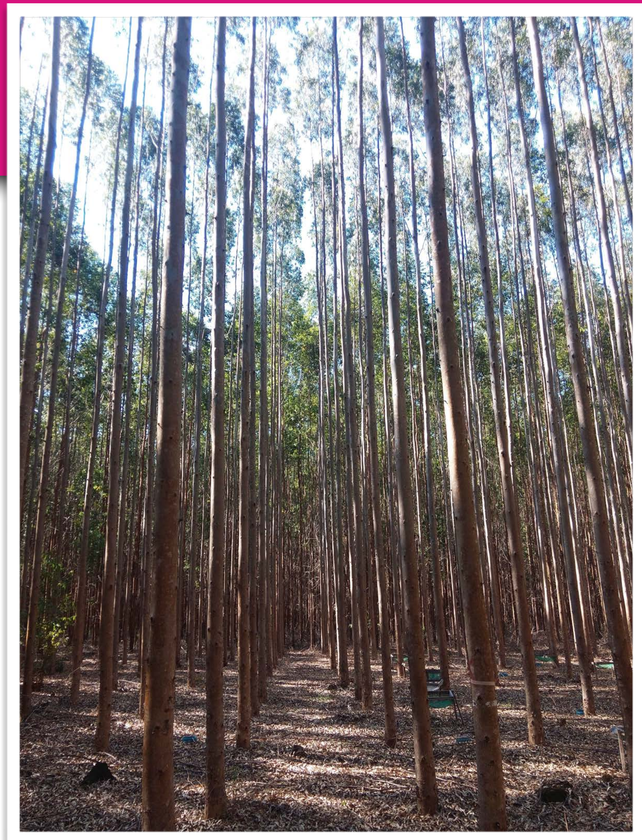

Wood phenotyping by NIR spectroscopy is particularly well-suited for breeding programmes where huge numbers of samples must be analysed or to screen unknown sample sets before wet chemistry analysis. Our objective here was to develop eucalyptus multispecies NIR calibrations for wood properties.

Materiel and methods

- More than 3,000 wood samples were collected for different eucalyptus species and hybrids from different ages of plantation (5-30 years old), and locations (Congo, Senegal, Madagascar, Brazil). NIR spectra of grounded samples stabilized at 12% of moisture content were measured in the diffuse reflectance mode with a Bruker spectrometer. More than 200 samples well-representing species, age diversity, and location were selected and Mahalanobis distance based on spectral data was used for largest sample set. Samples were subjected to extraction in a soxhlet apparatus with ethanol and then water to deduce extractive content. The Klason lignin, acid soluble lignin, alphacellulose and holocellulose contents were determined by adapted Tappy standard methods or by pyrolysis analysis for lignin and SG ratio depending of samples. The basic density and moisture content were measured on solid samples from Brazilian samples according to standard methods. Partial Least Square regressions were done and the models were tested by cross-validation with few groups (4-6).

Results and discussions

- Based on "Standard Error of Prediction" and "Ratio Performance Deviation" criteria our NIR calibrations showed good fits for all properties especially extractives, lignin, basic density, moisture content. According to William (2014), most of the model were classified from fair to excellent.
- Even if monospecific models are more accurate usually, our results suggest that multispecies calibrations could be useful to predict wood properties for different eucalyptus species including origins and age variabilities. Moreover, these could be useful to evaluate wood properties for new species not included in our calibrations and select unknown samples which could be added or to build monospecific calibrations.

Table I: Results of NIR models by cross validation for Eucalyptus wood properties (MC: moisture content, BD: basic density, TE: total extractives, HO: holocellulose, CE: alpha-cellulose, ASL: acid soluble lignin, PL: py-lignin, PSG: py-Syringyl/Guiacyl ratio, RMSECV: Root Mean Square of Cross-Validation, R^2_{CV}: Coefficient of determination, Rank: number of factors, RPD_{CV}: Ratio of performance deviation, CV: cross validation, py: pyrolysis analysis).

Nb specie	Properties	N	SD	Mean	min	max	RMSECV	R^2_{CV}	Rank	RPD_{CV}
4	MC	1142	2.5	13.5	8.9	21.4	0.63	0.93	5	4.0
10	BD	1389	0.110	0.492	0.330	0.888	0.035	0.90	6	3.2
5	TE	185	4.1	7.6	2.7	20.6	1.3	0.90	3	3.2
6	HO	168	6.0	63.6	41.4	75.6	2.4	0.84	4	2.5
6	KL	187	3.8	29.2	22.8	40.2	1.1	0.92	4	3.6
6	ASL	157	0.9	4.1	1.6	6.2	0.4	0.82	10	2.4
6	CE	150	3.5	35.5	26.7	42.6	1.5	0.83	4	2.4
1	PL	104	1.6	29.2	26.5	32.7	0.6	0.88	4	2.8
1	PSG	109	0.2	1.7	1.7	2.2	0.1	0.82	5	2.3

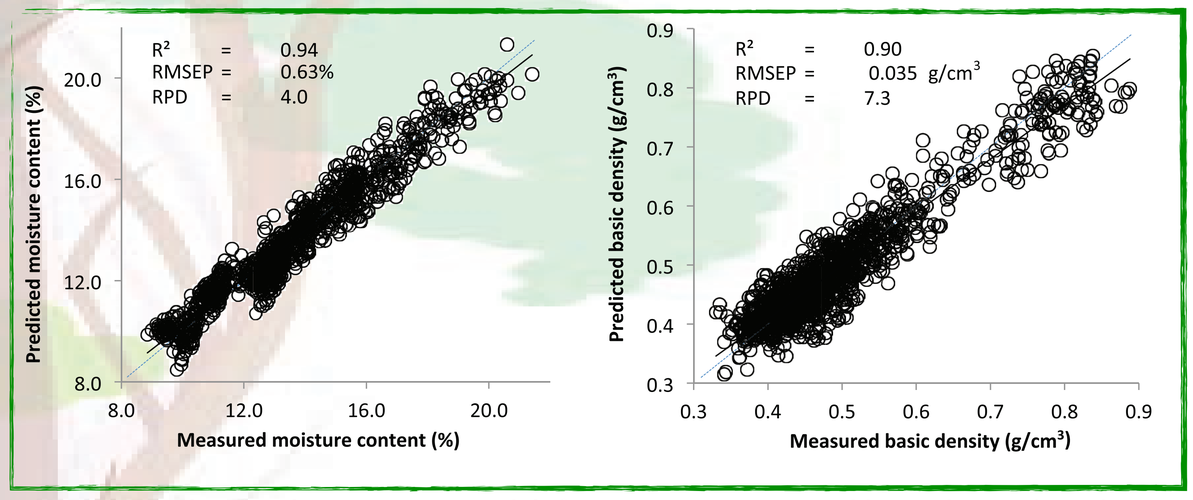

Figure 1: Results of multispecies NIR models for moisture content and basic density (*Eucalyptus grandis, E. resinifera, E. cloeziana* and *Corymbia maculata*) - Comparison of measured values from the lab and predicted values (cross-validation) by NIR from solid wood spectra.

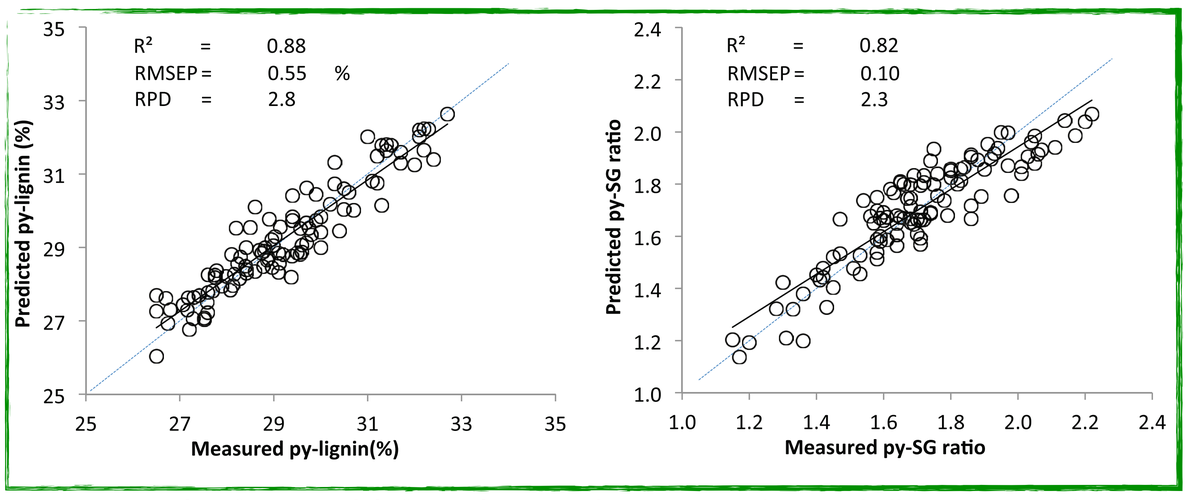

Figure 3: Results of NIR models for py-lignin and py-SG ratio (*E. urophylla x E. grandis*) - Comparison of measured values from the lab and predicted values (cross-validation) by NIR from grounded wood spectra.

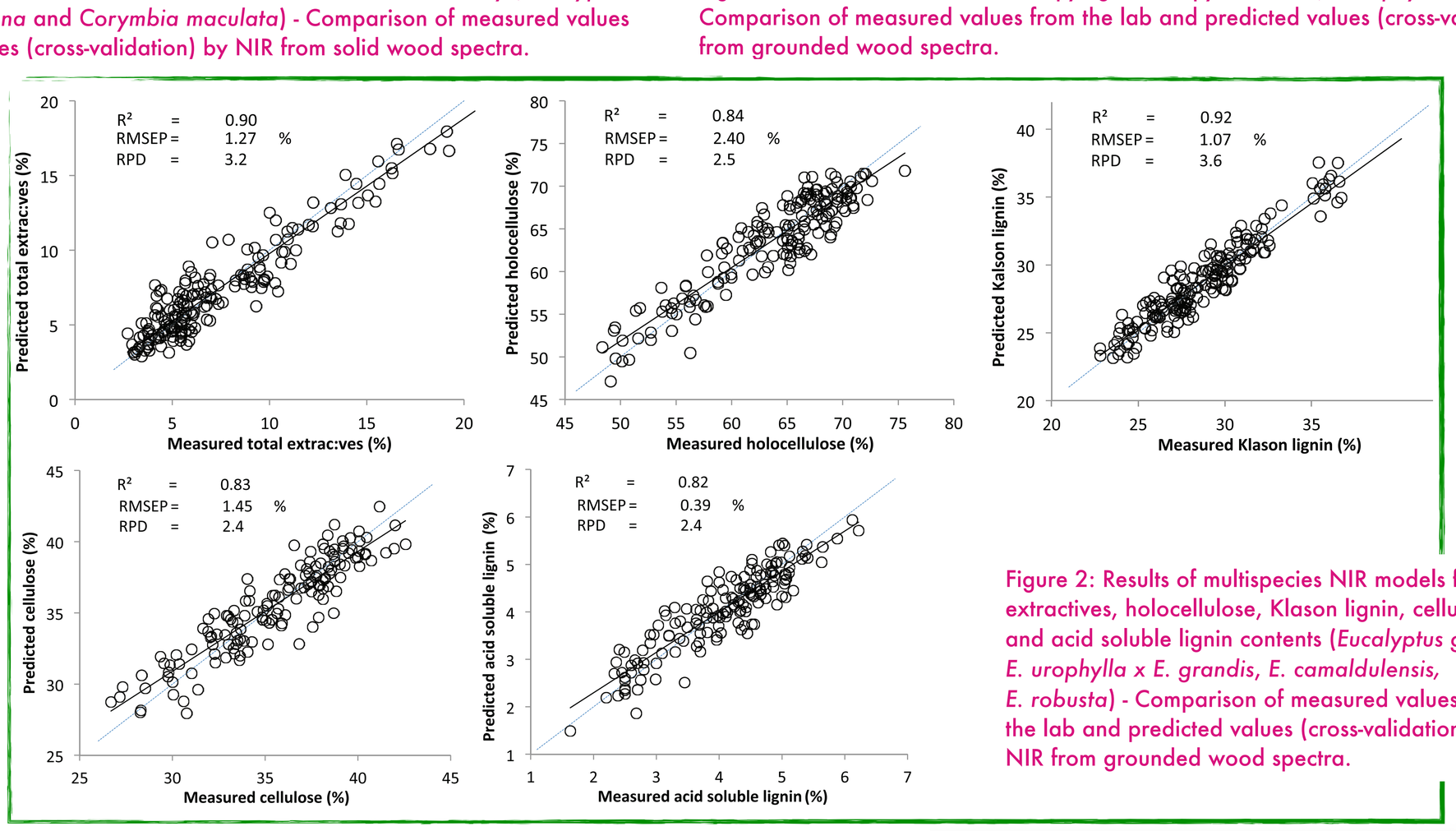

Figure 2: Results of multispecies NIR models for extractives, holocellulose, Klason lignin, cellulose, and acid soluble lignin contents (*Eucalyptus grandis, E. urophylla x E. grandis, E. camaldulensis, E. robusta*) - Comparison of measured values from the lab and predicted values (cross-validation) by NIR from grounded wood spectra.

Reference

William P. 2014. The RPD statistic: a tutorial note. NIRS News. 25:1.

Acknowledgements. This research has received funding by Agropolis Fondation under the reference ID 1203-003 through the « Investissements d'avenir » programme (Labex Agro/ANR-10-LABX-0001-01), FAPESP (2013/25642-5, 09/53951-7), and from Bureau Océan Indien de l'AUF, through SPIRMADBOIS project (S0194COV705HA).